Water quality status of Gajah Wong River, Indonesia

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Abstract. A high increase of population growth alongside of Gajah Wong River in Yogyakarta had induced water quality degradation. Human activities along riversides, such as domestic, agricultural, and industries such as leather discharge their wastewater directly in the river and are reducing water quality. The aim of the study is to analyze water quality and the water pollution index of Storage and Retrieval of Water Quality data System (STORET) index of Gajah Wong River. The determination of water quality was carried out from April to October 2019 at 7 sites along the Gajah Wong River, based on purposive random sampling. Secondary data of its water quality from the year 2006 to the year 2018 had been collected to be compared with the recent data. The data of the water quality was then analyzed using STORET method. The parameters analyzed were chemical oxygen demand (COD), biological oxygen demand (BOD), dissolved oxygen (DO), and total dissolved solids (TDS). Based on the data from 2019, the water quality parameters in Gajah Wong River exceeded the water quality standards, particularly in chemical parameters (nitrite, phosphate, chlorine, and BOD), as stated in Government Regulation No. 22 (2021) concerning the protection and management of water quality. According to the STORET index (a value of -14), the river is classified as moderately polluted, particularly for Class I use (source for drinking water), and Class II use (for agriculture and fisheries). Appropriate management must be developed to improve water quality.
Key Words: river class, STORET, water pollution.

Introduction. Water and sanitation are very important for living organisms, the availability of clean water and sanitation is goal number 6 in the Sustainable Development Goals (SDGs). Freshwater ecosystems such as lakes and rivers have important roles in providing freshwater in terrestrial ecosystems. The role has been included in the Sustainable Development Goals 2030, point 6: Clean Water and Sanitation (UN 2016). Ecologically, freshwater ecosystems function as source of drinking water, irrigation for agriculture, tourism, and habitat for aquatic organisms. Freshwater ecosystems also keep the balance of terrestrial ecosystems. However, there are threats to water quality that are caused by both natural and anthropogenic activities (Rahim & Soeprobowati 2019).

The economic growth in Indonesia has impacted environmental problems, notably river pollution (Resosudarmo 2003). Several rivers in Indonesia, such as Ciliwung and Bengawan Solo in Java, Musi in Sumatra, and Mahakam in Kalimantan have been seriously polluted from nonferrous metal waste, steel, fishing, and pesticide (Resosudarmo 2003). Rivers in Surabaya also experienced the same pollution caused by domestic and industrial waste (Noor & Soedjono 2019). The same issues also happened in Yogyakarta's rivers as well, such as Code, Winongo, and Gajah Wong (Saraswati et al 2019).

Gajah Wong River is one out of nine rivers in Yogyakarta that is classified into two types of rivers based on Yogyakarta Special Region Province Government Decree No 22 (2007) about river water quality class. Gajah Wong River, located in Hargobinangun area, is classified as Class I and can be used to obtain drinking water. Gajah Wong River in the Ngaglik, down to the meeting point with the Opak River in the Wonokromo region, is included in Class II, used for water recreation, freshwater fishing and farming, animal husbandry, and irrigation (BLH 2016).

Gajah Wong River is one of the rivers that is affected by pollution due to domestic and industrial waste disposal, the leather tanning industry, high levels of urbanization, and excessive use of pesticides (Riswanto et al 2017). The impact of this condition causes the decrease of the water quality. The utilization of water sources that is not used properly according to the determined river class will lead to health problems due to the presence of toxic compounds and pathogens harmful for the human body. The pollution indicators of Gajah Wong can be biologically, chemically, and physically observed (Nugrahaningrum et al 2017). The increase of pollution loads which enter the river can rise the nutrient levels and it will lead to eutrophication, which continuously reduces the water quality and threatens the survival of the organisms in the river.

The aim of the study is to determine water quality in Gajah Wong River. The assessment used Storage and Retrieval of Water Quality data System (STORET) method (The Decree of the Minister of Environment Republic of Indonesia No. 115 (2003) concerning guidelines for determining water quality status). The monitoring is useful to compare the changes of water quality of Gajah Wong from 2006 to 2019. This information can be useful as a tool to consider the most suitable strategy for Gajah Wong River management.

Material and Method

Description of the study sites. The research was conducted from April to October 2019 on the Gajah Wong River, Yogyakarta Special Region Province. The location is in the Gajah Wong watershed which is a sub-watershed of Opak River which has an area of about 38.3 km^2 (Putro 2014). Gajah Wong watershed is administratively located in the Sleman Regency in the upstream area that includes Pakem and Ngemplak districts. The middle stream area is in Yogyakarta, and the downstream area is in Bantul. Samples were collected at 7 stations: Tanen Village, Palgading, Balerejo Bridge, Muja-Muju (Gembira Loka Zoo) Kota Yogyakarta, Tegal Gendu Bridge, Giwangan Bridge, and Wonokromo respectively, based on the purposive random sampling. Those sites represent the upstream, middle stream, and downstream of Gajah Wong River (Figure 1).

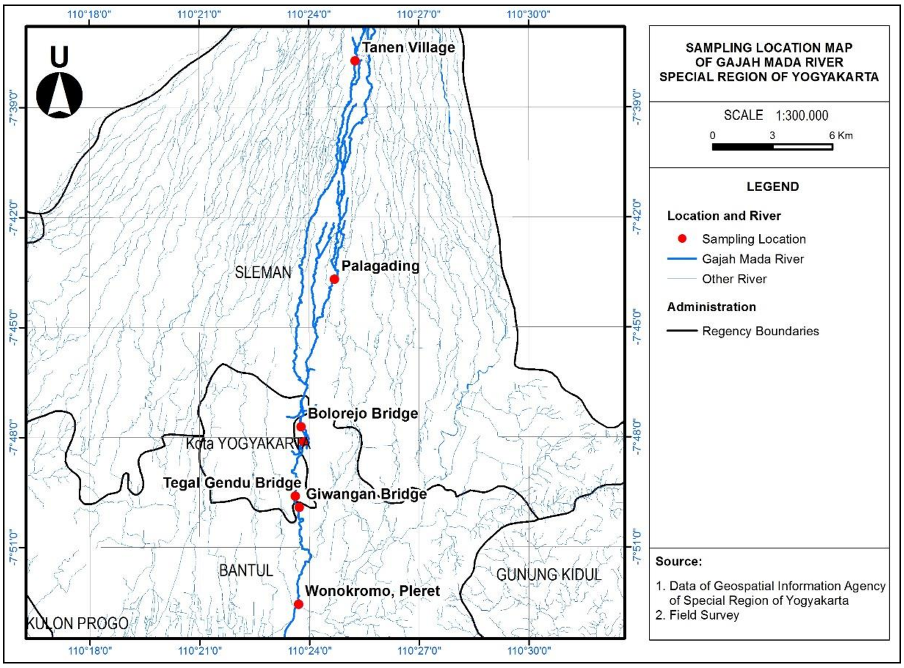

Figure 1. Research sampling location in Gajah Wong River, Yogyakarta, Indonesia (Geospatial Agency of Special Region of Yogyakarta 2020).

Several tools and materials were used to conduct the research. GPS (Global Positioning System) and a map of the location of Gajah Wong River were used to determine the sampling sites. The instrument used to measure environmental parameters was a Horiba device that can measure pH, oxidation reduction potential (ORP), conductivity, turbidity, dissolved oxygen (DO), total dissolved solids (TDS), temperature, salinity, and depth. The tools used to take phytoplankton samples and to identify phytoplankton are the 2.2 liter Van Dorn bottle, used to collect water samples at a depth of more than 1,5 meters, sample bottles, plankton net, label paper, cool boxes, digital camera, microscopes, deck glass, cover glass, 10 mL pipette, micropipette, and phytoplankton identification book. Four percent (4%) lugol solution was used to preserve phytoplankton samples.

Procedures. The data used to compare the water quality of Gajah Wong River are based on secondary data from year 2006 (BLH 2006), year 2007-2012 (Putro 2014), year 2014 (BLH 2014), year 2015 (BLH 2015), year 2016 (BLH 2016), year 2017 (Masduqi et al 2017), and year 2018 (Hardhaka 2019). The water quality of Gajah Wong River in 2019, was measured in-situ using Horiba water checker, conducted from April to October 2019. The data were compared to see the alteration of water quality in the Gajah Wong River.

Water quality analysis*.* The measurement of the water quality index for the river was analyzed using the STORET method referring to The Decree of the Minister of Environment Republic of Indonesia No. 115 (2003) concerning guidelines for determining water quality status. The basic principle of the STORET method is to compare water quality with water quality standards according to the designation to decide the water quality status of an area. The value system is presented in Table 1 and it is classified into four classes.

Table 1

Classification of water quality based on US-EPA (The Decree of the Minister of Environment Republic of Indonesia No. 115 2003)

Score	*Class*	*Water quality characteristic*
0	A	Meet the quality standards
-1 to -10	B	Lightly contaminated
-11 to -30	C	Moderately polluted
≥ -30	D	Heavily polluted

Determining the status of the water quality using the STORET method can be carried out in the following stages: (1) collecting water data from the maximum, minimum, and average values of physical, chemical, and biological parameters. (2) Obtaining the values from each water quality parameter are compared with the standard values according to the water class. (3) If the value of the measurement results meets the value of the water quality standard (measurement result ≤ quality standard) then the given score is 0. (4) If the measured value does not meet the value of the water quality standard, then the score is given according to the Table 2. (5) Water Quality Index of STORET is the total score that obtained using the defined score system of the remain score. (6) According to the total score, the water quality can be determined based on Table 1.

Table 2
Determination of water quality status value system (The Decree of the Minister of Environment Republic of Indonesia No. 115 2003)

Total of data	*Value*	*Parameters*		
		Physical	*Chemical*	*Biological*
< 10	Maximum	-1	-2	-3
	Minimum	-1	-2	-3
	Average	-3	-6	-9
≥ 10	Maximum	-2	-4	-6
	Minimum	-2	-4	-6
	Average	-6	-12	-18

Results

Total dissolved solids. TDS is described as the number of mineral salts and organic compounds in the water solution. The principal elements are generally chlorides, magnesium, sodium and potassium cations and carbonates, sulfate and nitrate anions, and calcium (Gellu et al 2015).

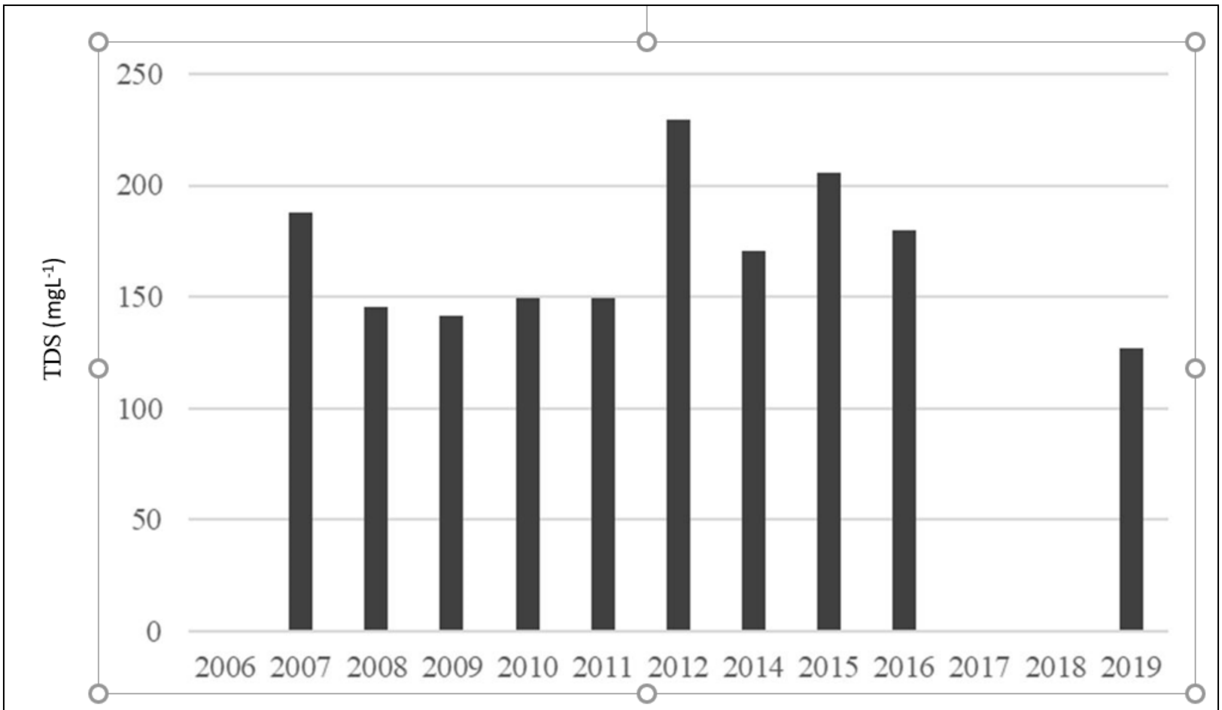

Figure 2. Total Dissolved Solids of Gajah Wong River graph from year 2007 to year 2019.

TDS values (Figure 2) from 2007 to 2019 are still below the water quality standard. The highest value was in 2012. The high number of TDS indicates an increased level of turbidity and determines the photosynthesis rate of autotrophic organisms, especially phytoplankton, to be inhibited. These conditions will reduce the supply of dissolved oxygen in water bodies. High TDS can also interfere with aquatic biota, such as fish, because the material will further impact from the declining rate of photosynthesis which is the decline in primary aquatic productivity and disruption of the entire food chain (Rahim & Soeprobowati, 2019). There is no data that can be found about TDS in year 2006, 2017 and 2018.

Based on analysis from this physical parameter (TDS) from year 2007 to year 2019, Gajah Wong River condition is in Class A which means its index meets the quality standard because the value of TDS is not over 1000 mgL^{-1}.

STORET analysis for chemical parameters from year 2006 to year 2019. The condition of the Gajah Wong River can be monitored from 2006 to 2019 regarding its physical parameters, Dissolved Oxygen (DO), Chemical Oxygen Demand (COD), and Biochemical Oxygen Demand (BOD). The result is used as an indicator for the chemical parameters particularly DO, COD, and BOD in Gajah Wong River for 13 years.

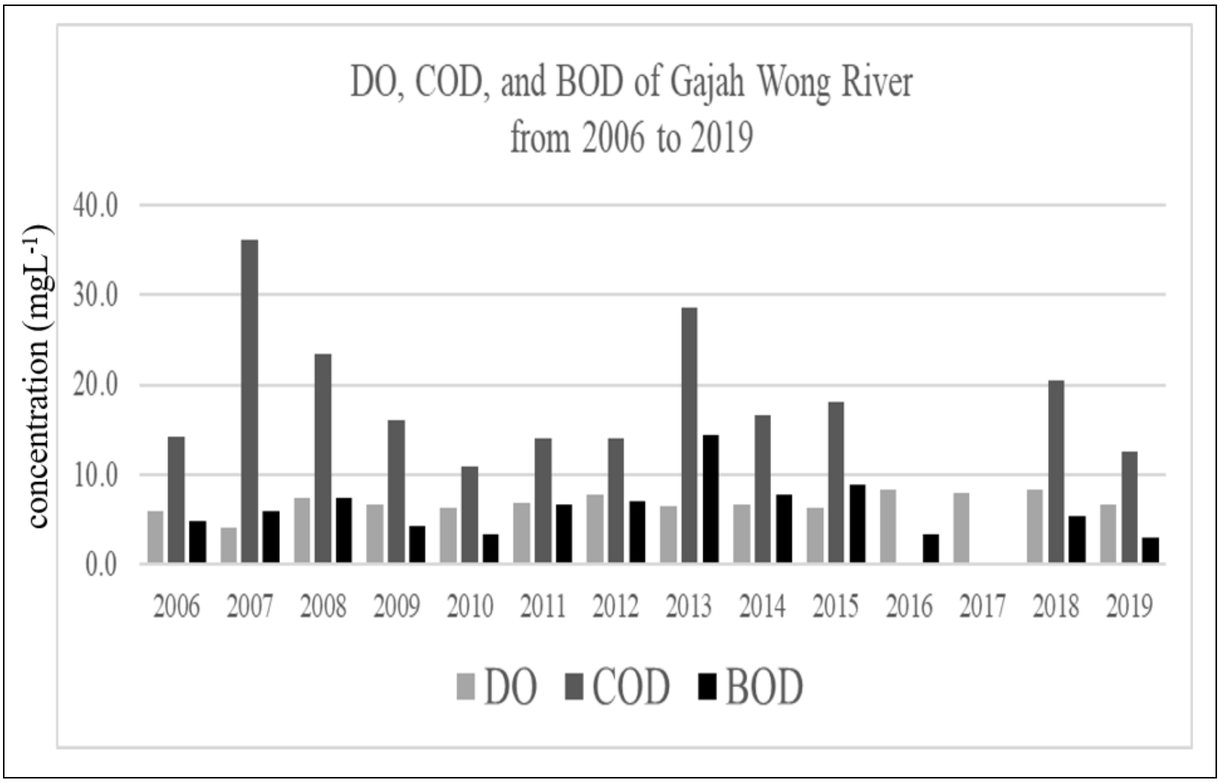

Figure 3. Dissolved oxygen (DO), chemical oxygen demand (COD), and biological oxygen demand (BOD) of Gajah Wong River 2006 - 2019.

Dissolved oxygen (DO). The amount of oxygen in a specific sample of water indicates the health level of a water body (McCaffrey 2015). The oxygen level varies depending on salinity, temperature, and water current. The higher the level of oxygen, it can be assumed that the rate of pollution in the water body is low. Oxygen levels can change daily and seasonally, depending on the movement of the water, the activity of the photoautotrophic organisms, the respiration of aquatic organisms, and the pollutants that enter the water body (Rahim & Soeprobowati 2019).

The presence of dissolved oxygen in the water can give an indication about the level of pollution in the water. The oxygen in the water is also used by aquatic biota to survive. The condition when there is low quantity of water and no oxygen, the aquatic organisms will die, consequently dissolved oxygen becomes an important limiting factor for their lives. If organic matter is abundant in a body of water, the decomposition activity increases and results in a decrease in dissolved oxygen because it is used in the decomposition process (McCaffrey 2015).

DO values (Figure 3) from 2006 to 2019 showed the highest DO value were in 2019, with 8.27 mgL^{-1}. This value is included in the Class I river classification group based on the Government Regulation No. 22 (2021) concerning water quality management and water pollution control. The lowest value occurred in 2007, which was 4,122 mgL^{-1}.

DO values from 2006 to 2019 tend to increase which means that the dissolved oxygen in the river has met the water quality standards. The higher DO value is related to the presence of oxygen which gives an indication that the level of pollution is low.

Chemical oxygen demand (COD). COD is described as the quantity of specific oxidants that react with a sample under controlled conditions (Hussain et al 2012). The quantity consumed by oxidants is expressed in oxygen equivalent terms. COD is also defined as the amount of oxygen needed in the chemical oxidation process and is expressed in units of mg O_2L^{-1}. COD measurement will get the amount of oxygen needed for the combustion process of organic compounds that are difficult to biodegrade. Organic compounds which are oxidized by potassium bicarbonate as a source of oxygen are converted into CO_2, H_2O, and chromium ions. Organic compounds that are resistant to biological decomposition, tannins, phenols, and polysaccharides can be found in the water body and so the measurement of COD is more appropriate than BOD (Rahim & Soeprobowati, 2019).

The COD standard for river criteria based on Government Regulation No. 22 (2021) for class I (source for drinking water) was at 10 mgL^{-1}, class II (or recreation infrastructure/facilities) at 25 mgL^{-1}, and class III (for fisheries) at 50 mgL^{-1}.

The highest value for COD (Figure 3) was recorded in 2007 (36,156 mgL^{-1}) and decreased until 2017, although in 2014 there was an increase, but it was still within the water quality standard limits for Class II. The high value of COD indicates the low river water quality due to the high number of organic compounds for living organisms such as fish and other aquatic organisms (Uddin et al 2014).

Biochemical oxygen demand (BOD). The value of Biochemical Oxygen Demand (BOD) is a chemical reaction used to measure the speed of biological organisms in using dissolved oxygen in the water bodies for the oxidation process of organic material from natural sources or pollutants and is expressed in mgL^{-1} or ppm. The source of BOD is organic carbon which can be broken down by living things (carbonaceous, CBOD) and ammonia (nitrogenous, NBOD). These compounds are the main constituents or metabolic waste products of autotrophic, heterotrophic organisms and human activities (domestic and industrial) (Penn et al 2013).

The disposal of waste with a high BOD level will cause water quality problems in a water body such as the decrease in DO level and the death of aquatic fauna. Water with a high BOD level gives an indication that the waters are polluted by organic matter. Based on Government Regulation No. 22 (2021), the BOD for a river that is categorized as Class 1 was 2 mgL^{-1}, Class 2 was 3 mgL^{-1}, and Class 3 was 6 mgL^{-1}.

The data from Gajah Wong River shows that the BOD level (Figure 3) from 2006 to 2017 had the highest value in 2014 which was 14.49 mgL^{-1}. This BOD level indicates that the condition of Gajah Wong River in 2014 exceeded the water quality standard threshold of the BOD parameter which is 12 mgL^{-1} for Class IV. This high rate can be an indication of high pollution levels because there are high activities that require oxygen from living things that decompose pollutants in the water. The more waste found in a water body, the higher the decomposition activity of waste by river water organisms. It gives an impact to the BOD level that will rise significantly. This pollution can occur due to the input of waste from various sources such as agriculture, industry, and households.

The lowest BOD value occurred in 2010 and 2017 at 3.42 mgL^{-1}. This value is categorized as still within the limits of Class II water quality standards. A low BOD value indicates no decomposition activity by aerobic organisms. This can be a sign that organic compounds from waste disposal are found in low levels.

Based on the COD, BOD, and DO from 2006 to 2019 with the STORET method analysis, the water quality of Gajah Wong River was in a moderately polluted water class (Class C), its index value is -14. Table 3 shows that BOD contributes with the highest pollution index with its index value being -10 in Gajah Wong River.

Table 3
Determination of water quality in Gajah Wong River from year 2006 to year 2019 using the STORET Method Analysis

Parameters	Measurement unit	Water quality standards				STORET calculation			Total	Sum Total	Status
		Class 1	Class 2	Class 3	Class 4	min	max	mean			
DO	mgL-1	6	4	3	0	-2	0	0	-2	-14	Class C (moderately polluted)
COD	mgL-1	10	25	50	100	0	-2	0	-2		
BOD	mgL-1	2	3	6	12	-2	-2	-6	-10		

Water quality analysis of Gajah Wong River in 2019. The measurement of the water quality can be an indicator of the condition of the river. It also can be an indicator of the condition of the biota and the activities of the society that live near the river. The parameters that can be used as the measurement consist of 26 parameters including physical and chemical parameters that were assessed from Gajah Wong River in year 2019. From the data, the condition of the Gajah Wong River in 2019 can be determined. According to this result, the highest pollutant in Gajah Wong River was phosphate, nitrite, chlorine, and BOD. The levels of phosphate, nitrite, and chlorine are high, more than the water quality standard that is regulated on Government Regulation No. 22 (2021) regarding Water Quality Management and Water Pollution Control. with values of BOD, phosphate, nitrite, and chlorine are higher than the water quality standard that is classified into Class II for fisheries. The value of BOD, phosphate, nitrite, and chlorine are 3.05 mgL^{-1}, 0.35 mgL^{-1}, 0.23 mgL^{-1}, and 0.035 mgL^{-1} respectively.

Nitrogen. Nitrogen affects species variation, abundance and nutritional content of animals and aquatic plants (Horne & Goldman 1994). Nitrogen in the form of nitrite (NO_2^-) and nitrate (NO_3^-) is one of the parameters that show fertility of an aquatic area. Both affect the nutrients that play a role in the formation of biomass of aquatic organisms and phytoplankton biomass as a water producer. Nitrate and nitrite values from the result show different values. Nitrite concentrations tend to increase along with decreasing rainfall level and the increase of population waste that is thrown into the river without proper processing.

The content of nitrites is higher than nitrates whereas nitrate compounds are more stable than nitrites. This happens because of insufficient oxygen to oxidize nitrites to nitrates. Nitrite values at the two stations are more than the water quality standard. Station 3 is a station located in Balerejo, in the middle of the city. Next to the river there is a fisheries academy. There are fishponds from which contaminants in the form of fish feed reach the body of water.

Phosphate. Phosphate compounds are limiting factors in the fertility of waters which is closely related to the composition of phytoplankton. The increase in phosphate compounds is influenced by nutrient intake from water catchment areas, activities of residents around the water body (river) and fishing activities.

The total P-content in the water column is influenced by particles originating from the mainland which enter the waters due to erosion and the activity of humans, atmospheric nutrients input and pH. Phosphorus plays a major role in biological metabolism because it is an important element for protein formation and helps cell metabolism. Thus, phosphorus is a factor limiting the capacity of waters as phytoplankton producers.

Nitrogen and phosphorus in freshwater play a role on increasing phytoplankton biomass, changes in phytoplankton community, benthic algal community changes, changes in the composition and biomass of macrophyte organisms, reduction of water transparency, affect the taste and aroma of water, decrease dissolved oxygen, increase the frequency of death fish, decrease the fish population consumption, and decline fish yields.

Chlorine. Chlorine, used as a bleaching agent and as a disinfectant, is poisonous to fish and other aquatic biota even at very low levels. In the middle of Yogyakarta city, there is a lot of household activity, textile factories, paper mills, and many laundry beaches. Chlorine can be used as a bleaching agent to those industries and can get in waterways from the source such as wastewater and industrial discharges and if the chlorine is not treated well before discharged, chlorine will reach the nearby river. The excess of chlorine enters the river where it combines with decaying material, forming other chemical compounds that can be cancer-causing to humans and pose a health threat to other organisms.

Conclusions. Water quality status according to the STORET method in Gajah Wong River, from year 2006 to year 2019, indicated that the river was moderately polluted (-14) for chemical parameters, and it met the water quality standard for physical parameters (0). The data of Gajah Wong River in year 2019 indicated that there were 4 parameters that exceed the water quality standard were phosphate, nitrite, chlorin, and biological oxygen demand.

Acknowledgments. The research was funded by the master's thesis research grant from the Directorate of Research and Community Service, Directorate General of Research and Development (Kemenristekdikti) with the contract number 258-11/UN7.P4.3/PP/2019. Thanks to Mirza Hanif Al Falah that help during field work.

Conflict of Interest. The authors declare no conflict of interest.

References

Gellu A., Rajitha J., Praveen P., Kumar J. V., 2015 Assessment of total dissolved solids and pH of wastewater, Musi River Study Area. International Journal of Research Studies in Science, Engineering and Technology 2(11):65-68.
Hardhaka T., 2019 [Water quality analysis of Gajah Wong River using biolistic method]. Institutional Repository of UIN Sunan Kalijaga Yogyakarta [in Indonesian].
Hussain S. A., Mahmood T., Ahsan A., 2012 Reduction of chemical and biochemical oxygen demand after treatment of pharmaceutical effluents. Pakistan Journal of Pharmacy 25(1&2):9-13.
Masduqi E., Setyorini H. B., Haryanti S., 2017 [Analysis of nitrate-phosphate compound of Gajah Wong Watershed, Special Region of Yogyakarta]. E-journal Institut Teknologi Yogyakarta, 11p [in Indonesian].
McCaffrey S., 2015 Water quality parameters and indicators. Namoi Catchment Management Authority, 6 pp.
Noor D. A. I., Soedjono E. S., 2019 Water pollution factor analysis and management in Surabaya River – Indonesia. IAETSD Journal for Advanced research in Applied Sciences VI (6):6–12.
Nugrahaningrum A., Harianja M. F., Nugroho H., Soesilohadi R. C. H., 2017 Macroinvertebrate diversity role in water quality assessment of Winongo and macroinvertebrate diversity role in water quality assessment of Winongo and Gajah Wong rivers, Yogyakarta, Indonesia. Bonorowo Wetlands 7(1):31-37.
Penn M. R., Pauer J. J., Mihelcic J. R., 2013 Biochemical oxygen demand. Environmental and Ecological Chemistry, II.
Putro S. S., 2014 [Water quantity and quality study (case study: Gajah Wong Watershed)]. Universitas Gadjah Mada: Thesis [in Indonesian].
Rahim A., Soeprobowati T. R., 2019 Water pollution index of Batujai Reservoir, Central Lombok. Journal of Ecological Engineering 20(3):219–225.
Resosudarmo B. P., 2003 River water pollution in Indonesia: An input-output analysis. International Journal of Environment and Sustainable Development 2(1):62.
Riswanto F. D. O., Hariono M., Susanto G. N., Budiasmoro I. Y. K., Istyastono E. P., 2017 Water quality assessment of Gajah Wong River Based on inhibition of acetylcholinesterase activity. Jurnal Manusia dan Lingkungan 24(2):89–94.

Saraswati S. P., Ardion M. V., Widodo Y. H., Hadisusanto S., 2019 Water quality index performance for river pollution control based on better ecological point of view (a case study in Code, Winongo, Gadjah Wong streams). Journal of the Civil Engineering 5(1):47–56.

Uddin M. N., Alam M. S., Mobin M. N., Miah M. A., 2014 An assessment of the river water quality parameters: a case of Jamuna River. Environmental Science & Natural Resources 7(1):249-256.

*** Geospatial Agency of Special Region Province of Yogyakarta, 2020 https://geoportal.jogjakota.go.id/pencarian?kategori=Referensi%20Spasial [Last accessed on 12 November 2020] [in Indonesian].

*** Republic of Indonesia Government Regulation No. 22, 2021 [The protection and management of water quality]. State Secretariat of Republic of Indonesia: Jakarta [in Indonesian].

*** Special Region of Yogyakarta Agency (BLH) Writing Team, 2006 [Information document on environmental management performance of Yogyakarta Special Region (DIY)]. BLH DIY [in Indonesian].

*** Special Region Province of Yogyakarta Government Decree No 22, 2007 [Special Region Province of Yogyakarta Government Decree No 22 year 2007 about river water quality Class]. https://dlhk.jogjaprov.go.id [Last accessed on 12 November 2020] [in Indonesian].

*** Special Region of Yogyakarta Agency (BLH) Writing Team, 2014 [Information document on environmental management performance of Yogyakarta Special Region (DIY)]. BLH DIY [in Indonesian].

*** Special Region of Yogyakarta Agency (BLH) Writing Team, 2015 [Information document on environmental management performance of Yogyakarta Special Region (DIY)]. BLH DIY [in Indonesian].

*** Special Region of Yogyakarta Agency (BLH) Writing Team, 2016 [Information document on environmental management performance of Yogyakarta Special Region (DIY)]. BLH DIY [in Indonesian].

*** United Nations (UN), 2016 Report of the inter-agency and expert group on sustainable development goal indicators. 47^{th} Session of the United Nations Statistical Commission. New York, USA.

*** The Decree of the Minister of Environment Republic of Indonesia No. 115, 2003 [Guidelines for determining water quality status]. Deputy Ministry of Environment for Policy and Environmental Institutions. https://luk.staff.ugm.ac.id/atur/sda/KepmenLH115-2003StatusMutuAir.pdf. [Last accessed on 7 September 2020] [in Indonesian].

Received: 26 March 2022. Accepted: 10 May 2022. Published online: 28 February 2023.
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How to cite this article:
Sefiasanti M. C. S., Soeprobowati T. R., Jumari, 2023 Water quality status of Gajah Wong River, Indonesia. AACL Bioflux 16(1):690-698.